



Cornell University



Damping Ring Magnets Report

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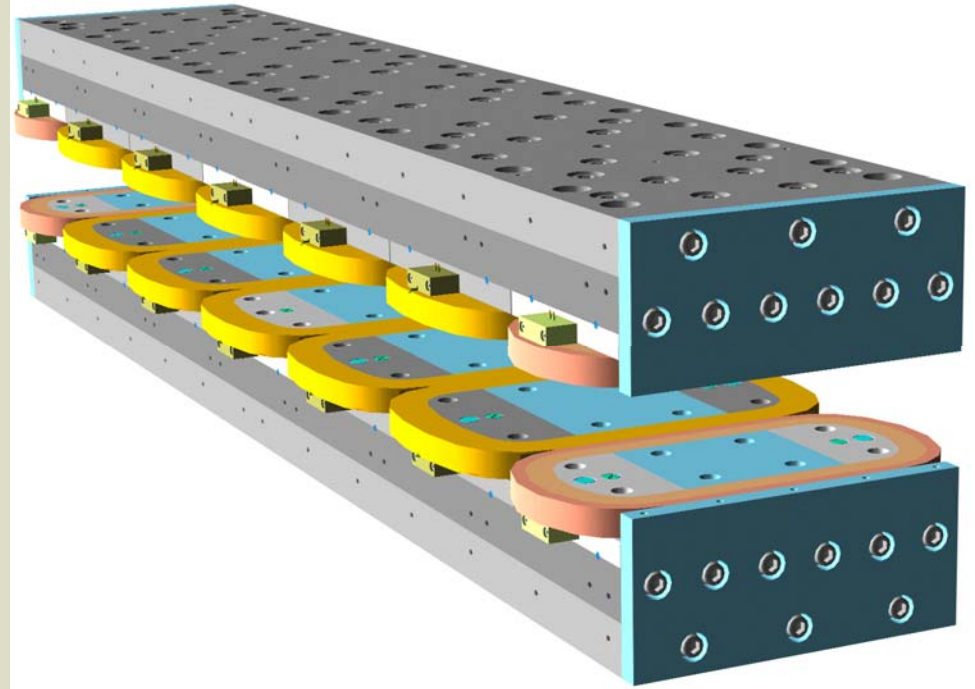
Outline

- **Wigglers**
 - CESR-c Wiggler
 - Key performance issues identified for Baseline Configuration Decision
 - Cost estimates used for BCD
 - Interface issues
- **Introduction to Damping Rings Group Reference Design Report Support**
 - DR Component Specification Sheets
 - Wiki site
- **Brief Conventional Magnets Overview**



CESR-c Wigglers

- **2.1 Tesla Peak Field**
 - Damping rate vs energy spread
- **50 mm Vertical Aperture**
- **0, -0.3% field uniformity**
 - +/- 20 mm electrostatically separated orbits
- **8-pole design installed**
 - 40 cm period
 - Offers better linearity versus excitation
 - However, has larger cubic non-linearity for fixed damping
- **a_1 skew quad moment**
 - Observed with both styles
 - Traced to variations in uniformity of coil geometry

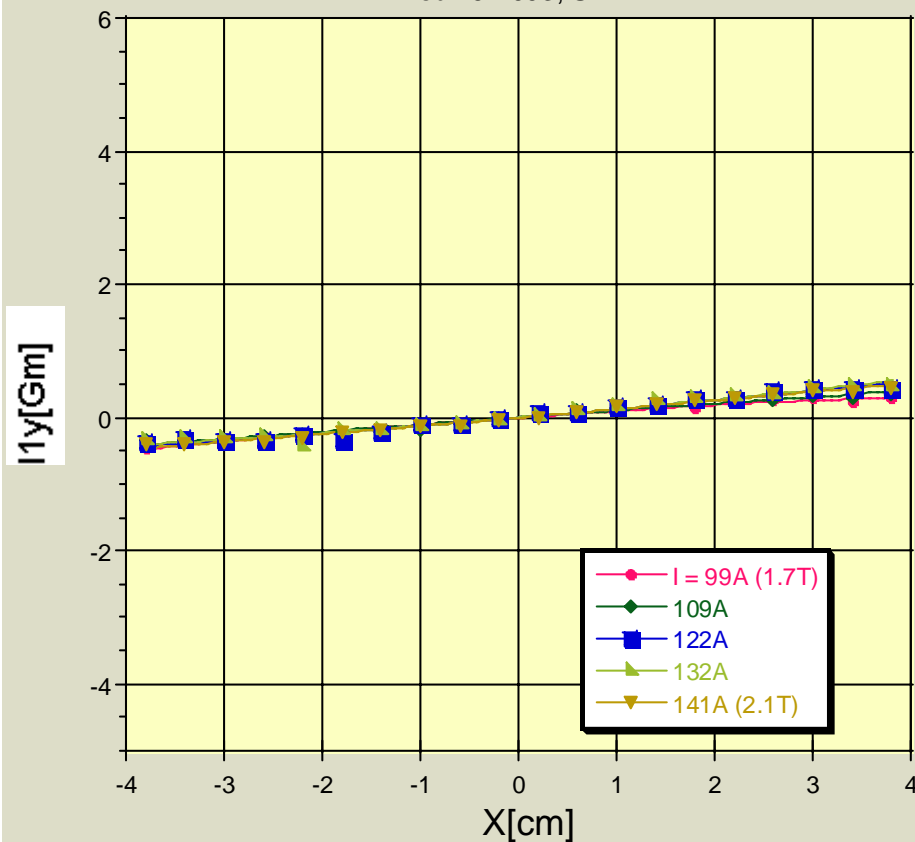


- **Single pole flux tests (warm) critical for final field quality**
 - 0.2 turn sensitivity
 - $O(10 \mu\text{m})$ in winding alignment
 - Pole matching

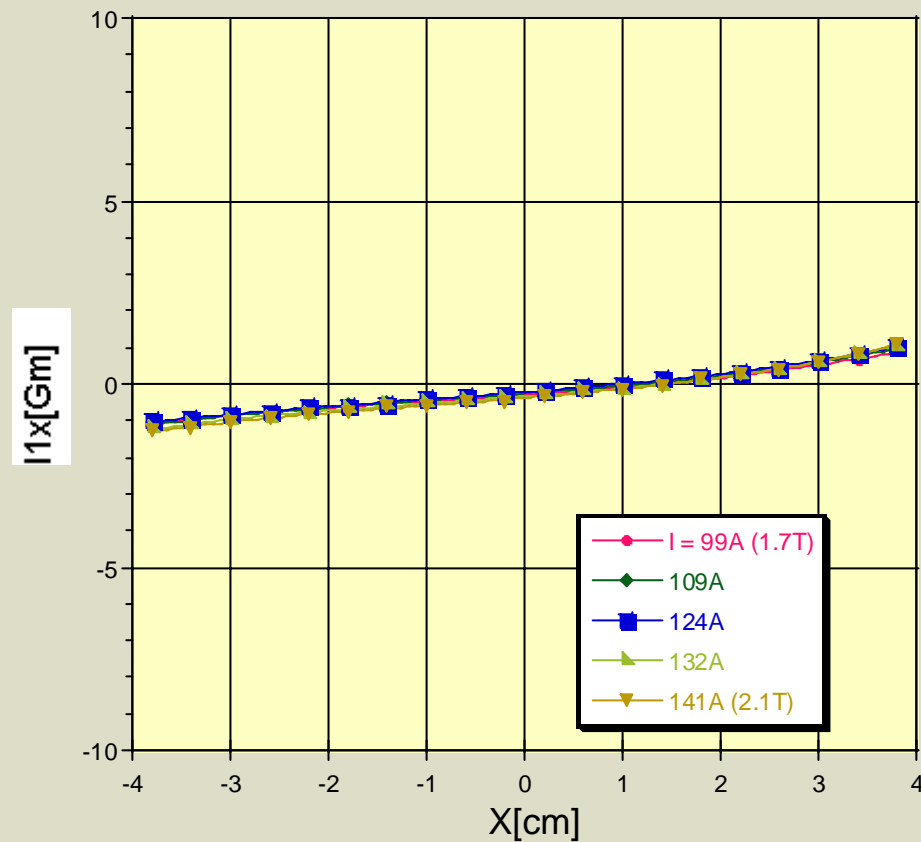


Flip Coil Measurements

Variation of I_1y versus x (Normal field integral, b_0 subtracted)
Wiggler #4 (8 Poles) magnetic measurement with a long flipping coil.
Feb 19 2003, ST



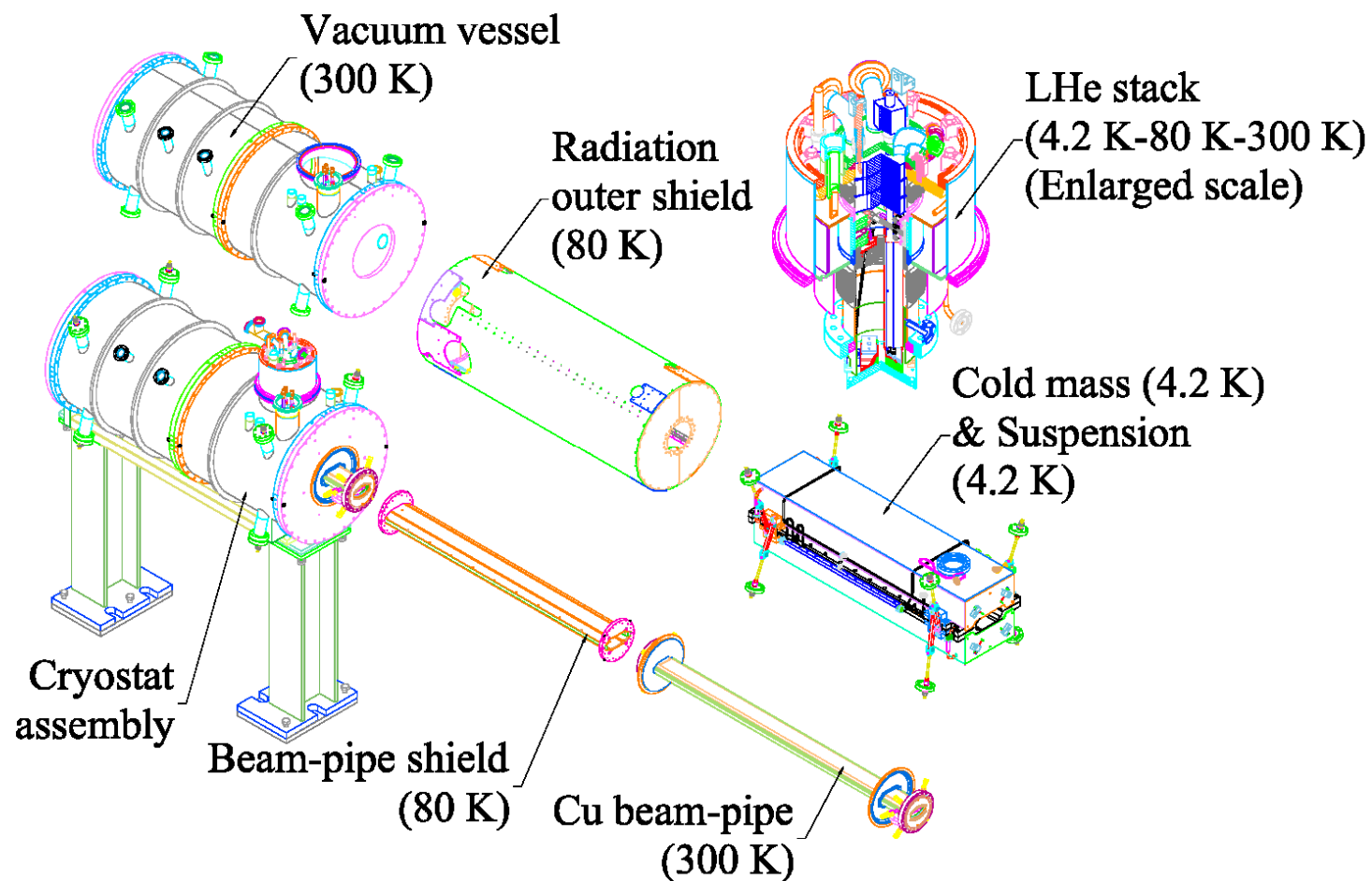
Variation of I_1x with x , (Skew field integral)
Wiggler #4 (8Poles) magnetic measurement with long flipping coil.
Feb 19 2003, ST



A. Temnykh

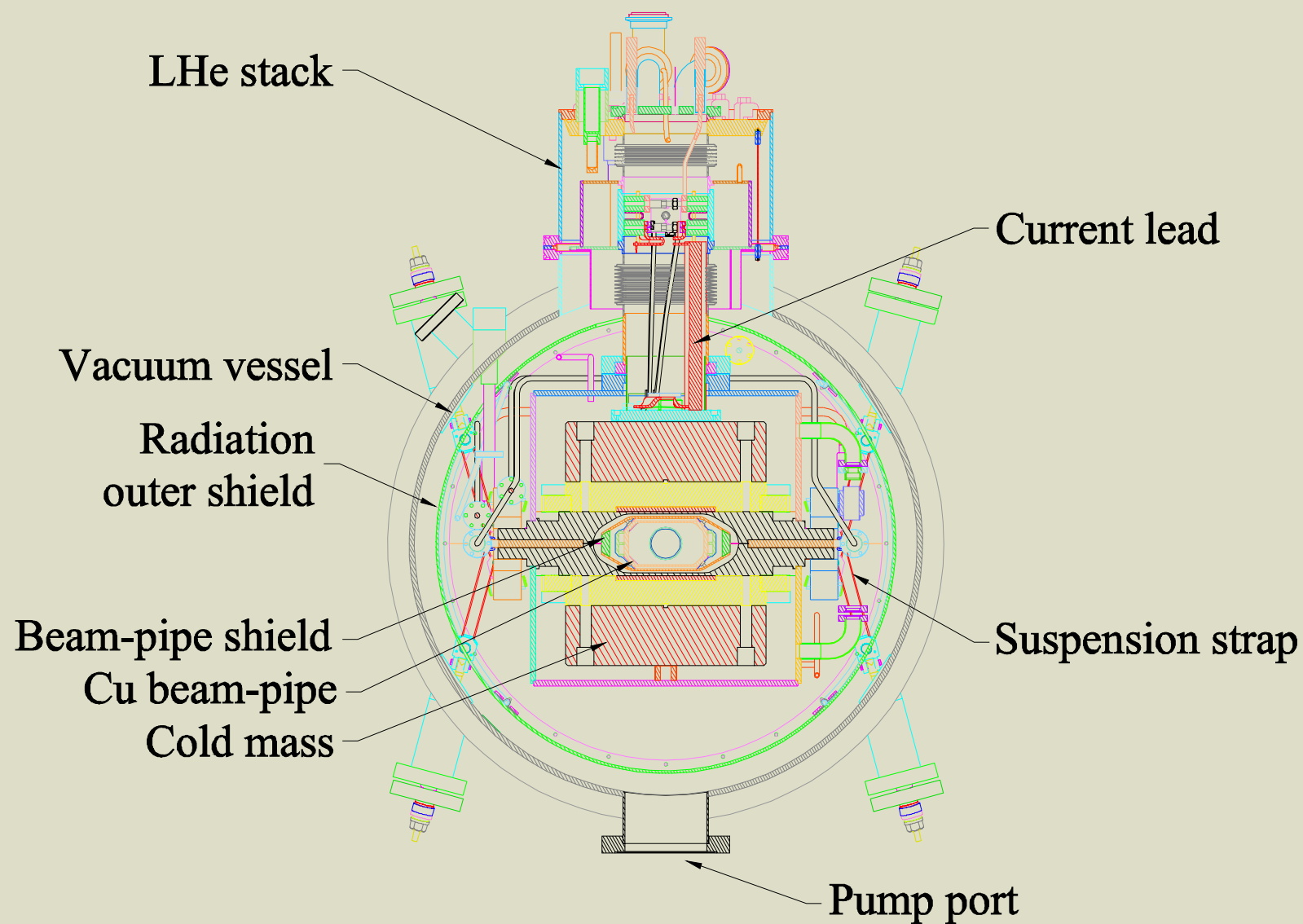


Magnet Assembly





End View





CESR-c Wiggler Features

- Capable of operation between 1.4 and 2.1 T
- Coils are bath-cooled
 - 4.2 K heat load is $\sim 2\text{W/m}$
- Magnets are trained
 - 2-3 quenches to reach full operating current
- High Temperature SC leads to minimize heat load
- LN_2 heat shield
 - Could be modified for cold He gas
 - What will ILC tunnel rules be?
 - Also used for pre-cool
 - LN_2 thermal load dominated by transfer lines
- Beampipe integral to cryostat assembly
 - Warm bore
 - Not bakeable



Damping Ring Considerations

- **Baseline Configuration Evaluation Matrix**
 - Field Quality: Exceeds requirements
 - Simulations indicate that keeping field roll-off at the $\sim 0.1\%$ level throughout beam envelope (3σ) is critical for dynamic aperture performance
 - Physical Aperture: 50 mm
 - Important for positron acceptance
 - Important for electron cloud performance
 - Power Consumption: Reasonable
 - Radiation Damage: Coils at large radius and well-shielded
⇒ looks OK
 - Auxilliary System: Cryogenics and Power
 - Cost: See following slides
 - Availability: See following slides



Wiggler Costing for BCD

- **CESR-c Wiggler Production Costs**
 - ~\$140K/meter for magnet/cryostat
 - ~\$20K/wiggler (stack and leads)
 - \$16K/wiggler power supplies and controls (electrical and cryo)
 - \$3-5K per wiggler (note 1 wiggler = 2-4 m) for transfer lines
 - Cryogenic capacity: ~\$2K/meter
 - \$160-170K/m capital cost depending on unit length
 - Power costs: ~\$1K/meter/year
- **Manpower**
 - 5.0 Senior FTE
 - 13 Technical Support FTE
 - Above costs use LBNL 2005 manpower rates
- **Numbers do not include initial engineering costs**



Availability

- **Short-term availability**
 - Single wiggler fault expected to have minimal impact on operations
 - $\Delta Q_v \sim 0.01/\text{wiggler}$
 - Retune and continue operations with $\sim 1\%$ degradation in damping time and $< 1\%$ change in emittance or maintain an in-ring spare
 - Superferric
 - PS failure
 - Cryogenic failure
 - Controls failure
 - Magnet failure
- **Expect minimal time required in a damping ring scenario to disable a wiggler and resume operations. Defer repairs until scheduled maintenance periods**
- **CESR-c Wiggler Experience**
 - Note: CESR wiggler fault requires full wiggler recovery before re-starting machine due to strong wiggler impact on optics ($\Delta Q_v \sim 0.1/\text{wiggler}$)
 - 11 wiggler faults in 300 operating days in mix of 6 wiggler and 12 wiggler operation
 - $\Rightarrow \sim 1$ fault/250 wiggler-days of ops
 - 7 cryogenic
 - 2 power supply
 - 1 controls
 - 1 quench
 - 2 hrs 14 min avg turnaround for full repair



Modification Areas

- **Unit Length**
 - OCS2 specifies ~2.5 m active length – twice CESR-c
 - Longer version of CESR-c being pursued
 - Might be 2 units end to end in single cryostat
 - Reduce helium stack costs
- **Beampipe**
 - Separate from cryostat for greater flexibility in preparation
- **Lower max field (1.67 T)**
- **Increase pole aperture**
 - Plenty of current and field quality overhead in present design
 - Simplifies support plate fabrication
 - Potentially could be used to provide increased bore space



Some Practical Issues

- Clarify procedures for specifying and costing required modifications to CESR-c design
- Interface issues are significant
 - Procedures for interfacing between technical groups
 - Design control procedures
 - Special documentation?
- Would like to specify procedures now, not later



Damping Rings RDR Support

- <http://www.lepp.cornell.edu/ilc>
 - Entry point for ILC support areas (Wiki) at Cornell
 - For example: WG3b, ILC-Americas, Detector Study
- **Damping Ring Support**
 - <https://wiki.lepp.cornell.edu/ilc/bin/view/Public/DampingRings/WebHome>
 - Follow RDR link to get to documentation and Component Specification Sheets
 - Just getting started
 - Very much a work in progress
 - Supporting documentation
 - Schematics
 - Papers
 - Perhaps discussion area for interface between technical groups?



Comp Spec Sheet Example

ILC Damping Rings Component Specification Sheet

Part I – General Information

Component Description:	Electron damping ring sextupole		
Component Location (beamline):	EDR		
Document Number:	EDR-MAG-sxt-001	Date:	2006-04-03
Prepared by:	Mark Palmer (Cornell)	email:	map36@cornell.edu
Technical/Global System:	Magnets		
Technical/Global System Contact:	John Tompkins (FNAL)	email:	jct@fnal.gov
DR Area System Contact:	Jie Gao (IHEP)	email:	gaoj@ihep.ac.cn

Part II – Main Parameters

Parameter	Value	Reference
Quantity per beamline	240	[1]
Name in MAD deck	SF	[1]
Nominal integrated strength k_2L	0.146 Tm ⁻³	[1]
Effective length	0.25 m	[1]
Pole-tip radius	0.03 m	[1]
Nominal pole-tip field	0.005 T	[1]
Coil resistance		
Current at nominal strength		
Power		
Unit Cost		

Part III – Other Parameters, Information, and Drawings

Field quality specifications [2]

n	systematic field error		random field error	
	b_n	a_n	b_n	a_n
4	2.0×10^{-4}		1.0×10^{-4}	
5	1.0×10^{-4}		3.0×10^{-5}	
6	7.0×10^{-4}		1.0×10^{-4}	
7	1.0×10^{-4}		3.0×10^{-5}	
8	1.0×10^{-4}		3.0×10^{-5}	
9	1.0×10^{-4}		3.0×10^{-5}	
10	1.0×10^{-4}		3.0×10^{-5}	
11	1.0×10^{-4}		3.0×10^{-5}	
12	3.2×10^{-3}		1.0×10^{-4}	
13	1.0×10^{-4}		3.0×10^{-5}	
14	1.0×10^{-4}		3.0×10^{-5}	

ILC Damping Rings Component Specification Sheet

Document Number: EDR-MAG-sxt-001

Date: 2006-02-08

Part IV – References

- [1] MAD deck (OCS v2, 23 March 2006).
[2] The multipole component is defined by:

$$\frac{\Delta B_y + i \Delta B_x}{|B(r)|} = \sum_n (b_n + i a_n) \left(\frac{x}{r} + i \frac{y}{r} \right)^{n-1}$$

A. Wolski, J. Gao, S. Guiducci, "Configuration Studies for the ILC Damping Rings," LBNL-59449, pp. 21-22 (February 2006).



New Lattice

- New lattice from ANL (OCS v2)
 - Available March 23rd
 - Have started preparing component specification sheets
- Quadrupole/Sextupole Overview

Arcs

Quad - QFA:	N = 240	L = 0.300	K1L = 8.56e-02
QDA:	N = 240	L = 0.300	K1L = -8.61e-02
Sext - SF:	N = 240	L = 0.250	K2L = 1.46e-01
SD:	N = 240	L = 0.250	K2L = -2.29e-01

Straights

Quad - QFI:	N = 26	L = 0.150	K1L = 3.84e-02
QDI:	N = 24	L = 0.150	K1L = -3.52e-02

Wiggler Sections

Quad - QFWH:	N = 112	L = 0.150	K1L = 9.50e-02
QDWH:	N = 80	L = 0.150	K1L = -8.51e-02

RF Sections

Quad - QFRF:	N = 16	L = 0.150	K1L = 1.07e-01
QDRF:	N = 32	L = 0.150	K1L = -9.46e-02

Dispersion Suppression Sections

Quad - QFMA1:	N = 20	L = 0.300	K1L = 9.96e-02
QDMA1:	N = 20	L = 0.300	K1L = -7.92e-02
Sext - SF1:	N = 20	L = 0.250	K2L = 0.00e+00
SD1:	N = 20	L = 0.250	K2L = 0.00e+00

Matching to Wiggler Sections

Quad - QFMT1:	N = 16	L = 0.300	K1L = 1.46e-01
QDMT1:	N = 16	L = 0.300	K1L = -1.76e-01
QFMT2:	N = 16	L = 0.300	K1L = 1.79e-01
QDMT2:	N = 16	L = 0.300	K1L = -1.87e-01

Matching to Straight Sections

Quad - QFMS1:	N = 2	L = 0.300	K1L = 1.05e-01
QDMS1:	N = 2	L = 0.300	K1L = -1.34e-01
QFMS2:	N = 2	L = 0.300	K1L = 7.07e-02
QDMS2:	N = 2	L = 0.300	K1L = -8.80e-02

Matching to Injection Section

Quad - QFMINJ1:	N = 2	L = 0.300	K1L = 7.61e-02
QDMINJ1:	N = 2	L = 0.300	K1L = -1.23e-01
QFMINJ2:	N = 2	L = 0.300	K1L = 7.23e-02
QDMINJ2:	N = 2	L = 0.300	K1L = -9.98e-02
QFMINJ3:	N = 6	L = 0.300	K1L = 6.41e-02
QDMINJ3:	N = 6	L = 0.300	K1L = -8.06e-02

Injection Section

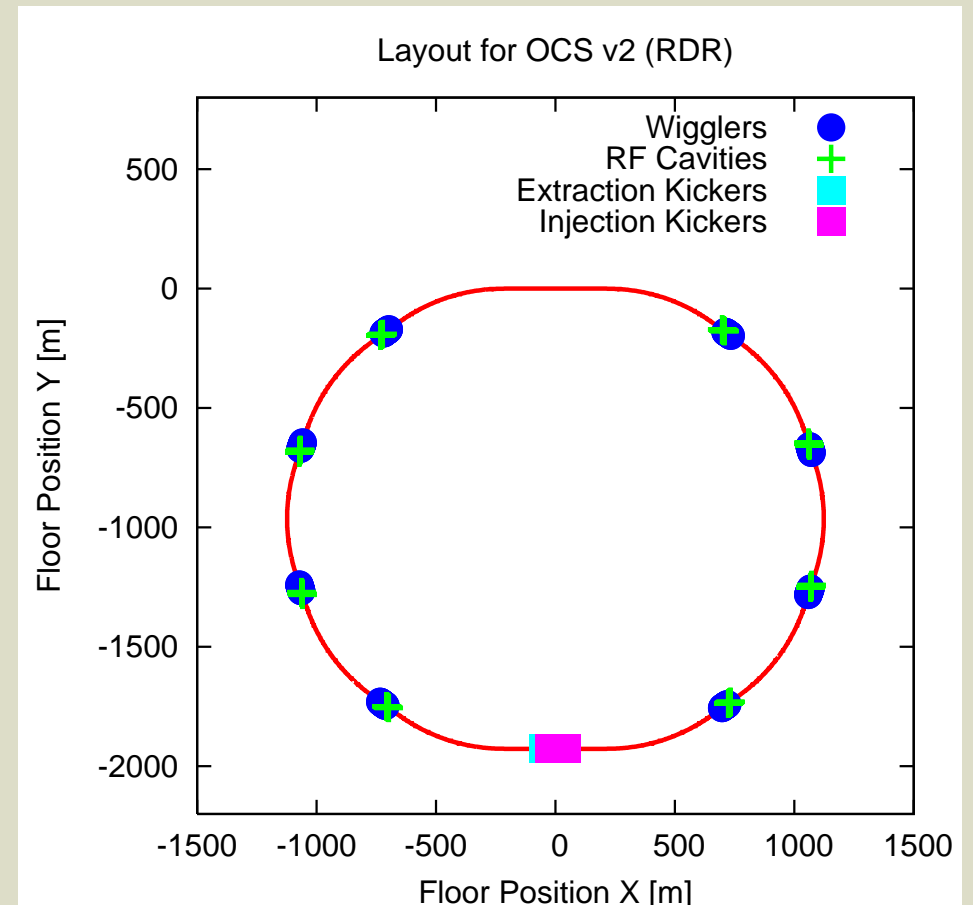
Quad - QFINJ1:	N = 8	L = 0.300	K1L = 1.69e-01
QDINJ1:	N = 8	L = 0.300	K1L = -2.17e-01
QFINJ2H:	N = 8	L = 0.150	K1L = 1.41e-01
QDINJ2:	N = 2	L = 0.300	K1L = -1.16e-01
QFINJ3:	N = 2	L = 0.300	K1L = 9.11e-02
QDINJ3:	N = 0	L = 0.000	K1L = 0.00e+00
QFINJ4H:	N = 4	L = 0.000	K1L = 0.00e+00
QFINJ5H:	N = 0	L = 0.000	K1L = 0.00e+00

Totals: n(QUAD) = 934 (32 types) ~783 physical quads
n(SEXT) = 520 (4 types)



OCS v2 Lattice

- Simulations with PEP-II multipole errors look satisfactory
 - Bend/Quad/Sext
 - Baseline error specification
- 8 wiggler/RF sections
 - 8 cavities
 - 10 wigglers





Summary

- **Wigglers**
 - Detailed design and costing information available for CESR-c wiggler
 - Need to quantify modifications for ILC DR use
 - Evaluate engineering/design issues
 - Specify procedures for design adjustment
 - Specify procedures for costing adjustment
- **General Magnets**
 - RDR support page up and running
 - Component specification sheets will appear over next few weeks
 - Supporting documentation will be provided simultaneously